Thromboembolic Events Associated with Coil Protrusion into Parent Arteries after GDC Treatment

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Summary

Aneurysm embolization using Guglielmi detachable coils(GDC) is gaining acceptance as a viable alternative to surgery in the treatment of cerebral aneurysms. During GDC treatment of cerebral aneurysms, thromboembolic events are the most frequent complications. As risk factors of thromboembolic events, large aneurysms, wide-necked aneurysms, use of the balloon-assisted technique and protruding coils into the parent arteries are previously reported. From March, 1997 till August, 2004, 270 consecutive patients were treated with GDC embolization at our institute. Fourteen (5.2%) patients with 14 aneurysms of these 270 patients presented with protruding coils into the parent vessels.

Twelve aneurysms of these 14 aneurysms were small (diameter <10 mm), and two were large (diameter 15 mm). Nine aneurysms had small necks (neck diameter <4 mm), and five had wide necks(neck diameter >4 mm). The fundus-to-neck ratio ranged from 1.04 to 2.78, with an average of 1.53.

In this series, ten patients (71%) were treated with balloon-remodelling technique because every patient had either a wide-necked aneurysm or complicated morphologic factors. These 14 aneurysms were divided into two groups according to the mode of coil protrusion, loop type and tail type protrusion. The first coil was protruded in five (36%) cases of 14 patients, four of these five cases presented with the loop type protrusion. The last coil was protruded in seven cases (50%), Five of these seven cases presented with the tail type protrusion. Diffusion-weighted imaging abnormalities were found for seven (50%) of 14 patients within 24 hours of the coiling procedures. Three (21%) of 14 patients showed small lesions (<5 mm) in the subcortical white matter at the border zone or perforating regions. In four (29%) patients, large territorial infarctions (>5 mm) were detected. Symptomatic complications occurred in four (29%) patients, and all of these four patients presented the loop type protrusion. One patient who had small infarctions experienced minimal deficits (slight motor weakness, quadrantic hemianopsia) after six days postprocedure and fully recovered by discharge after stronger systemic heparinization (24000 U, for three days), aspirin (100 mg/day) and Ticlopidine (100 mg/day). Three patients who had large territorial infarctions experienced moderate deficits.

Two patients were treated with stronger systemic heparinization and one with Argatroban (60 mg/day, for two days), and following aspirin (100 mg/day) and Ticlopidine (100 mg/day). Finally, two patiens were discharged with permanent minimal deficits (hypoesthesia only) and one with moderate hemiparesis. The infarctions related to the GDC procedures were more com-

mon sequelae in wide-necked aneurysms and coil protrusions, especially loop type protrusion. Although permanent neurological deficits were rare, the high rate of thromboembolic events associated with coil protrusion suggest that more aggressive medical treatment should be considered.

Introduction

Aneurysm embolization using Guglielmi detachable coils (GDC) is gaining acceptance as a viable alternative to surgery in the treatment of cerebral aneurysms[1-5]. During GDC treatment of cerebral aneurysms, thromboembolic events are the most frequent complications[6-7]. As risk factors of thromboembolic events, large aneurysms, use of the balloon-assisted technique and protruding coils into the parent vessels are previously reported[8-11]. Because there are few reports of coil herniations previously, we present fourteen cases of coil herniations and discuss clinical outcomes and the treatment about thromboembolic events.

Despite the relatively high frequency of thromboembolic events associated with coil herniation after GDC treatment, postprocedure thromboembolism is not well understood. This information may help guide future efforts at reducing the risk involved in endovascular treatment of cerebral aneuysms. The purpose of this retrospective review was twofold.

1) to determine whether any clinical, anatomical, or pharmacological factors were associated with either coil herniation into the parent vessels or postprocedure ischemic events.

2) to determine the adequate anticoaguration treatment against postprocedure ischemic events.

Patient and Methods

Patient Population

From March, 1997 till August, 2004, 270 consecutive patients were treated with GDC embolization at the University of the Ryukyus, and its affiliated hospitals, Okinawa, Japan. Fourteen (5.2%) of 270 patients presented with protruding coils into the parent vessels. Twelve patients were female and two were male. Their ages ranged from 37 to 81 years (mean age 63.4 years). Four patients presented with subarachnoid haemorrhage (SAH) and unruptured aneurysms were identified incidentally in the remaining ten patients. Patiens were informed of the alternative therapies and signed consent forms.

Aneurysm Description

The aneurysms presented with coil protrusion were at the following locations: internal carotid-paraclinoid segment (n = 8), internal carotid-opthalmic aneurysms (n = 2), internal carotid bifurcation aneurysms (n = 2), basilar artery aneurysm (n = 1), and middle cerebral artery bifurcation aneurysm (n = 1). The size, neck diameter, and fundus-to-neck ratio of the aneurysms were measured. A wide-necked aneurysm was defined as one having a neck diameter > 4 mm or a low fundus-to-neck ratio (close to 1 or < 1.5).

Procedure for Treatment of GDCs

All GDC embolization procedures were performed with the patient under general anesthesia. A single 7F femoral sheath or bilateral 6F femoral sheaths were used when balloon remodeling technique was necessary. The guiding catheter was positioned in the internal carotid artery or vertebral artery, and the microcatheter was introduced through the guiding catheter and navigated into the aneurysm by using a fluoroscopic road map. GDCs were placed under fluoroscopic guidance using standard techniques. After placement of each coil, angiography was performed to assess the degree of aneurysm obliteration, to assess the evidence of coil protrusion into parent artery, and to search for signs of thromboembolic phenomena. The results of the embolization were classified into complete occlusion (no filling of aneurismal rests without neck remnant) or incomplete occlusion (small neck remnant or partial occlusion).

Medical Adjuncts to the GDC Procedure

After the placement of femoral sheaths, all patients, except patients with ruptured aneurysms, were systemically anticoagulated with intra-venous (IV) administered doses of heparin (typically 5000U) to achieve prolongation of the activated clotting time (ACT) to > 2.5 times baseline.

In patients with ruptured aneurysms, systemic heparinization was delayed until after the successful placement of the first coils. Evaluating the ACT was repeated at least each hour through the procedure, and repeat boluses of

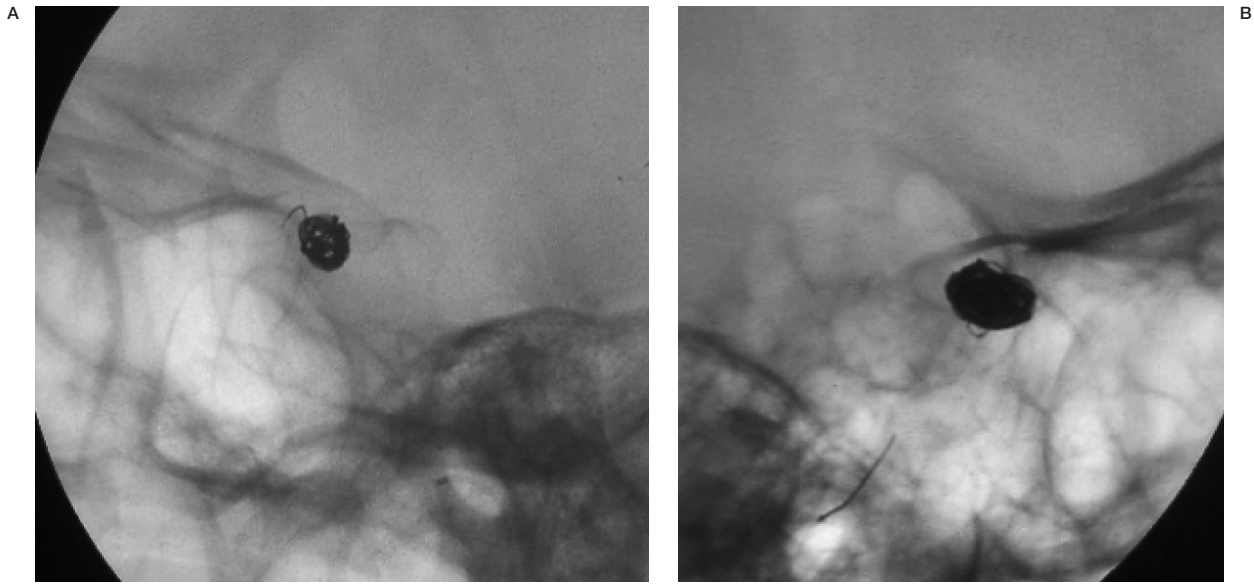

Figure 1 Type of coil protrusion. A) Tail type, B) Loop type.

heparin (routinely 1000U) were administered as necessary to maintain the ACT at 2-3 times baseline throughout the procedure. Patients were kept systemically anticoagulated with heparin (typically 12000 U/day) or Argatroban (30 mg/day) for two days postoperatively. Patients with coil protrusion were received stronger postprocedure treatment, such as heparin (24000 U/day) for three days or Argatroban (60 mg/day) for two days. The administration of aspirin (100 mg/day) was begun on the first postoperative day routinely. In addition, ticlopidine(100 mg/day) was administered for the patients with coil protrusion.

Diffusion-weighted MR Imaging

MR imaging was performed with 1.5T system within 24 hours of the GDC embolization procedures. All patients underwent our acute stroke imaging protocol, which includes axial T1-weighted, T2-weighted, fluid-attenuated inversion-recovery imaging and diffusion-weighted imaging. If diffusion-weighted imaging abnormalities were seen, their number, location, and size were recorded.

Surgical Reports

The surgical reports of the GDC procedure were reviewed for the following information.

1) the aneurysm dimensions (mean diameter, neck size and fundus-to-neck ratio)

2) the use of balloon remodeling technique

3) volume ratio

4) the pattern of coil protrusion that is, protruded like the tail (tail type) or protruded loops of coil (loop type) (figure 1).

Results

Clinical, Technical and Angiographic Findings

From March, 1997 till August, 2004, 270 consecutive patients were treated with GDC embolization at our institute. Fourteen (5.2%) of the 270 patients presented with protruding coils into the parent arteries (table 1,2). Among these 14 patients, four patients presented with acute SAH and the remaining ten patients presented with unruptured aneurysms.

The size of the aneurysms ranged from 2.7 to 17 mm, with a mean size of 7.4 mm in the largest angiographic dimension. Twelve aneurysms were small (diameter <10 mm), and two were large (diameter 15 mm). The size of the neck of aneurysms ranged from 2.5 to 6.25 mm, with a mean of 3.6 mm. Five aneurysms showed neck diameter more than 4 mm. The fundus-to-neck ratio ranged from 1.04 to 2.78, with an average of 1.53. Nine aneurysms showed low fundus-to-neck ratio (close to 1 or <1.5). Wide-necked aneurysms (neck diameter >4 mm or fundus-to-neck ratio close to 1 or

<1.5) were eleven (79%) of 14 aneurysms with coil protrusion.

In this series, ten patients (71%) were treated with balloon-remodeling technique because every patient had either a wide-necked aneurysm or complicated morphologic factors. The first coil was protruded in five (36%) cases of 14 patients. Four of these five cases presented with the loop type protrusion. The last coil was protruded in seven cases (50%) of 14 patients. Five of these seven cases presented with tail coil protrusion.

DWI Findings and Treatment

Diffusion-weighted imaging(DWI) abnormalities were found for seven (50%) of the 14 patients with coil protrusion within 24 hours of the GDC embolization procedures. These hyperintense lesions were located in the ipsilateral side of the treated aneurysms. Three (21%) of the 14 patients showed small lesions (<5 mm) in the subcortical white matter at the border zone or perforating regions. Four (29%) of the 14 patients showed large territorial infarctions (>5 mm). Symptomatic complications occurred in four (29%) of 14 patients with coil protrusion. All of these four patients presented the loop type of coil protrusion. One patient who had small infarctions experienced minimal deficits (slight motor weakness, quadrantic hemianopsia) after six days postprocedure and fully recovered by discharge after systemic heparinization (24000 U/day, for three days), and administration of aspirin (100 mg/day) and Ticlopidine (100 mg/day). Three patients who had large territorial infarctions experienced moderately deficits. Two patients were treated with systemic heparinization (24000 U/day, for three days) and one with Argatroban (60 mg/day, for two days), and following aspirin (100 mg/day) and Ticlopidine (100 mg/day). Finally, two patiens were discharged with permanent minimal deficits (hypoesthesia only) and one with moderate hemiparesis.

Discussion

Significant advances have been made during the past decade in endovascular techniques for the treatment of intracranial aneurysms, resulting in wide acceptance of GDCs for treatment of saccular intracranial aneurysms. Technical

Table 1 **Clinical, Technical and Angiographic Findings.**

	age/sex	AN location	AN size	Neck size	F/N ratio	Ballon assist
1	75/F	IC-Opthalm	4.6 x 7.9 x 4.8	3.4	1.35	
2	64/M	BA	4.5 x 5 x 5.8	2.9	2	+
3	75/F	IC Top		6.25	1.2	+
4	65/F	IC Top	4.1 x 4.1 x 4.3	3.1	1.39	
5	65/M	IC PC	4 x 4 x 3	2.5	1.2	+
6	37/F	IC-Opthalm	14 x 16 x 14	4.9	2.78	+
7	37/F	IC (C2)	8.7 x 10.3 x 7.0	4.2	1.67	+
8	56/F	IC (C2)	3.2 x 6.4 x 4.1	3	1.37	+
9	42/F	IC (C2)	6.1 x 5.0 x 5.5	3	1.81	+
10	48/F	IC (C2)	5.0 x 5.1 x 6.0	3	2	
11	52/F	IC (PC)	3.0 x 4.2 x 5.4	2.7	1.04	+
12	52/F	IC (C2)	4.2 x 4.2 x 5.4	4.1	1.32	+
13	52/F	IC (C2)	5.0 x 7.5 x 5.0	4.5	1.11	+
14	91/F	MCA	2.7 x 2.7 x 2.9	2.5	1.16	
mean	63.4 y.o		max. 7.4 mm	3.6 mm	1.53	

complications associated with the use of GDC include aneurysmal perforation and rupture, parent artery occlusion, cerebral embolism, coil migration, vasospasm, and haemodynamic ischemia with inadequate collateral reserve [8-11]. The largest contributor to morbidity and mortality rates in GDC treatment has been iatrogenic brain ischemia caused by thromboembolic events [6-7]. Thromboembolic events ranging from transient ischemic attacks to major strokes occurred in 1.0-28% of the cases in several clinical series [1-5]. The complications in these studies were defined as new focal deficits, a change in mental status, or abnormalities at postprocedural CT or conventional MR imaging. Pelz et Al. have suggested that thromboembolic events resulting from GDC embolization procedures may be even more common than previously reported in the literature [6]. In their experience, thromboembolic events associated with conventional GDC embolizations occur at a frequency of 28%, with persisting deficits affecting approximately 5% of patiens. DW imaging appears to be the most sensitive technique for detecting early and small ischemic lesions. Biondi et Al. reported that two of 20 patients had new lesions detected with DW imaging [12]. The rate of thromboembolic complications in this study was 10% (two of 20). More recently, Soeda et Al. published results in which DW imaging showed hyperintense lesions in 40 (61%) of 66 patients, with 16 patiens (40%) eventually developing neurologic deterioration [13-14]. In our experience, DW imaging was performed in 226 of 270 patients, 106 (47%) of 226 patients presented with hyperintense lesions, and 12 (5.3%) patients showed new neurologic deficits ranging from transient ischemic attacks to major strokes. The rates of postprocedure thromboembolic events at DW imaging and neurological deteriorations significantly lower than the rates reported previously.

As risk factors of thromboembolic events, large aneurysm, wide-necked aneurysm, use of the balloon-assisted technique and protruding coils into the parent arteries are previously reported. In this study, ten (71%) of 14 patients with coil protrusion were treated with balloon-remodeling technique, and these ten patients presented with a wide-necked aneurysm, four of these ten patients experienced neurological deteriorations.

The mechanism behind the association of large aneurysm with thromboembolic events is unclear. Large aneurysm may predispose to thromboembolic ischemic events by two possible mechanisms. First, large aneurysms treated with GDCs are more likely to have residual flow within coil mass than small aneurysms. A second hypothesis is that this higher risk is simply related to the greater volume of thrombus in larger aneurysms, resulting in an increased risk of distal embolization.

In wide-necked aneurysms, incidence of ischemic events after GDC embolization has been reported to occur with greater frequency. A wide aneurysmal neck may promote propagation of thrombi by providing a larger coil surface area on which to form or greater access of thrombus formed in the aneurismal sac to the parent artery.

Balloon-assisted techniques increase the likelihood of thromboembolic complication for several reasons. The introduction of two guiding catheters and two microcatheters in the same artery, the temporary occlusion of the parent artery, repeated inflations and deflations of the balloon, and the necessity of a substan-

Table 2 **Technical and Clinical Outcome.**

	VER	coil hernia	HI lesion	Ischemic event	Treatment
1	41.1	1st coil			
2	20.9	last coil	+	tensient	heparin
3					
4	29.5	last coil			
5	23.7	1st coil	+	permanent	heparin
6	17.1	1st coil			
7	18.9	last coil	+	permanent	heparin
8	32.3	1st coil			
9	16.2	1st coil	+		
10	20.9	last coil	+		
11	45				
12	18.3	last coil			
13	39.2	8th coil	+	permanent	argatroban
14	52.3	last coil	+		

tial amount of treatment material (coil packing) being exposed to the bloodstream all contribute to the perception that balloon-assisted techeiques carry a risk greater than those of embolization tequniques without balloons. Some authors have suggested that balloon-assisted techeiques cause ischemic lesions more frequently than conventional GDC treatment. Soeda et Al. investigated thromboembolic events associated with coil embolization with DW 13 imaging. They reported that thromboembolic complications were more common in procedures utilizing balloon-assisted techniques than in procedures using conventional GDC techniques (73% vs 50%).

However, others, such as Moret et Al. and Lefkowitz et Al., have reported lower rates of thromboembolic complication when balloon-assisted techniques are used. Recently, Albayram et Al., reported that DW imaging depicted thromboembolic events associated with balloon-assisted embolization in 20% of their 15 cases. This rate of complication is significantly lower than the rates reported by Soeda et Al. and Rordorf et Al. (61% in both cases). Whether the risk for thromboembolic events with balloon-assisted technique increase now remain controversy.

Previous investigators have suggested that protrusion of coils increase the risk for subsequent stroke. Colin et Al. reported that coil protrusion occurred in 21 (13%) procedures of 159 GDC embolization procedures, and that coil protrusion occurred in four of the nine patients with postprocedure thromboembolic eleven events. In our experience, fourteen (5.2%) of the 270 patients treated with GDC embolization presented with protruding coils into the parent arteries. Our study showed significantly lower rates of protruding coils into parent arteries than the rates reported by Colin et Al. (13% vs. 5.2%), and that lower rates of postprocedure thromboembolic events in patients with coil protrusion (57% vs. 33%). In this study, DW imaging was performed in 226 of 270 patients, 106 (47%) of 226 patients presented with hyperintense lesions, and 12 (5.3%) patients showed new neurologic deficits ranging from transient ischemic attacks to major strokes. The rates of postprocedure thromboembolic events with coil protrusion in both cases (57% reported by Colin et Al. and 33% by present study) were extremely higher than the rates without coil protrusion. In 14 patients with coil protrusion. symptomatic thromboembolic complications occurred in four patiens (29%). All of these four patients presented with the loop type of coil protrusion. It is likely that these loop type of coil protrusion serve as a site for platelet aggregation, leading to local thrombosis or distal thromboembolism. Patients with coil protrusion were received stronger postprocedure treatment, such as heparin (24000 U/day) for three days or Argatroban (60 mg/day) for two days. The administration of aspirin (100 mg/day) was begun on the first postoperative day routinely. In addition, ticlopidine (100 mg/day) was administered for the patients with coil protrusion. One patient who had small infarctions experienced minimal deficits fully recovered by discharge after systemic heparinization (24000 U/day, for three days), and administration of aspirin (100 mg/day) and Ticlopidine (100 mg/day). Three patients who had large territorial infarctions experienced moderately deficits. Two patients were treated with systemic heparinization (24000 U/day, for three days) and one with Argatroban (60 mg/day, for two days), and following aspirin (100 mg/day) and Ticlopidine (100 mg/day).

Finally, two patiens were discharged with permanent minimal deficits (hypoesthesia only) and one with moderate hemiparesis.

Conclusions

The infarctions related to the GDC procedures were more common sequelae in wide-necked aneurysms and coil protrusions, especially loop type protrusion. Although permanent neurological deficits was rare, the high rate of thromboembolic events associated with coil protrusion suggest that more aggressive medical treatment should be considered.

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